IMPLEMENTATION OF BOILER BEST PRACTICES

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ABSTRACT

Boilers are an essential part of any industrial plant, and their efficient, economical operation can significantly affect the reliability and profitability of the entire plant. Best Practices for Boilers include tools to determine where a plant or corporation is with respect to boiler treatment, what needs to be done to make the plant (corporation) the "best of the best," and how to get there. When implemented, Best Practices provide a method to measure and track progress, and represent a benchmark for continuous improvement.

Best Practices combine our global collective experience from the areas of research, consulting, sales and marketing, and involve not only recommendations and specifications, but also the rationale behind them for the application of the chosen treatment, monitoring, and instrumentation. Best practices provide energy savings, profitability improvement, reduction in total cost of operations, project management, optimized treatment choices, enhanced safety, system assessment processes and facilitated system improvements.

INTRODUCTION

Boilers are a crucial component of every plant, regardless of size or of product produced. Maintaining peak boiler reliability and consistent system performance while minimizing energy costs can be a challenge for any utility operation. Implementing Best Practices for Boilers can assist in gathering information to benchmark systems, then measure and track progress once changes are made within the plant/corporation.

There are several steps in the effective implementation of Best Practices for Boilers. Knowing the status of the system from a treatment point of view, as well as from monitoring and instrumentation, is the first step in benchmarking the system and improving system reliability and economics. This paper will discuss several examples of the implementation of Best Practices, and the benefits derived in improving boiler system efficiency, safety, and performance, and in reducing total cost of operations. The discussion is meant to make the reader aware of the steps in, and benefits of, Best Practices, rather than to fully define the details involved in each implementation.

WHAT ARE BEST PRACTICES?

Nalco Boiler Best Practices condenses Nalco's global collective experience into a single, consistent, supportable reference (the Boiler Best Practices Manual) to guide the field representative and customer working with industrial boiler systems. This includes the expertise of boiler and turbine manufacturers, and the research and development work of such industry organizations as the Electric Power Research Institute (EPRI) and the American Society of Mechanical Engineers (ASME) to produce a comprehensive document.

Nalco Boiler Best Practices provide a benchmark for continuous improvement of our customers' systems. They take into account the need for improvements in profitability, boiler system efficiency, safety, and performance, and the need to reduce total cost of operations. Manuals, graphs, surveys, questionnaires, monitoring and instrumentation guidelines, recommendations and specifications, and diagrams for the systems used in conjunction with plant personnel all help to move closer to the target.

Cycle diagrams of the feedwater, boiler water, steam and condensate systems form the framework upon which the Best Practices are built. These diagrams do not specify a chemical treatment, but provide the requirements for proper treatment, monitoring and control given a certain feedwater quality, i.e., mixed bed or two bed demineralization, or softened water--and program choice. The performance monitoring includes both commercially available and proprietary technology capable of providing real-time feedback on chemistry control and contaminant detection.

The manual includes detailed information on various chemical programs, the monitoring approaches available, and the reasons why one would be a better (or required) choice given the system conditions. Chemical feed systems as well as diagnostic testing and upset contingencies are covered, as are special situations such as lay-up and chemical cleaning.

A Best Practices questionnaire is filled out during a boiler (or plant) audit/survey to determine compliance with Boiler Best Practices, and opportunities for improvement. Questionnaire results are maintained in a database so that comparisons can be made within a corporation or within an industry. These comparisons can be with overall industry-specific averages, or within a segment of an industry, such as pulp and paper mills with recovery boilers or refineries producing ethylene. Comparisons can also be made based on boiler operating conditions, like looking at 600 psig boilers within an industry or across industry lines.

WHY CONSIDER BEST PRACTICES?

There are many factors that are important to plant management, regardless of industry. The order of importance has been changing over the past few years, and may be different from industry to industry, but profit, performance, safety, and environmental concerns continue to top the list.

Unlike some non-critical operations within a plant, which could cause problems and fines, but will not usually shut a plant down, having a boiler down unexpectedly will certainly curtail, if not stop, production. Since a plant's profitability is generally tied to its ability to make product, repeatedly having one or more boilers down will adversely affect short- and long-term viability. An improperly run boiler can also cause emission problems resulting in production curtailment and/or fines, which impacts a plant's operations and profitability, and has potentially negative environmental consequences. Excess energy use due to poor performance affects the total cost of operations and all problems with boilers potentially cause safety concerns, for workers, the plant, and the community.

That being said, Best Practices for Boilers provides a means and the tools to improve all four factors while maintaining or improving total cost of operations.

Examining plant operations in light of Best Practices with surveys and the Best Practices compliance questionnaire, often leads to a new perspective on operations. Best Practices provides an objective framework and set of questions to assist in evaluating and benchmarking boiler systems. A fresh outlook can often point out deficiencies that have not been noticed because "everything is running fine," or "we have always done it that way and it has worked OK," and so on. Plant operations are measured, and the data gathered is documented, in light of current operations and how they differ from "Best Practice" for that portion of the boiler system.

Once sufficient data has been gathered, metrics can be set for a plant or for a corporation. Metrics can include process variables such as steam load, condensate return, cycles of concentration, operations issues such as turbine outages and boiler cleanings, chemical and manpower costs, and so on. It is important that these metrics are agreed-upon costs for each item and that the plant (or corporation) and the on-site consultants/vendors agree on the value of each item, (e.g., the value of 1 gpm of clean, hot condensate). This makes it much easier to determine the value of each improvement project, and the return on investment for each project.

Decisions are facilitated at all levels of management in the plant because the choices are clearer with additional information. The information gathered during the discovery process helps to get buy-in from plant management for projects, and is used to determine and justify costs associated with changes in treatment and capital. The decision comes down to whether to change operations or to continue with the status quo. If changes are desired, they can be ranked in terms of priority of implementation. These decisions are made based on <u>information</u>, not supposition, and take into account the safety, economics, efficiency, and ease of implementation of each recommendation for change that arises from a Best Practices survey. The outcome should be a determination of reduction in total cost of operations, improved profitability, performance, and/or safety improvement, or some combination thereof.

Repeating the survey and questionnaire on a periodic basis, (i.e, every 6-12 months) allows tracking of progress made toward the "Best Practice." This can help to ensure that the highest priority projects are being worked on. Returns from the projects such as improved profitability, reduced cost of operations, improved safety, and reduced maintenance and downtime can be calculated.

IMPLEMENTING BOILER BEST PRACTICES

Implementing Boiler Best Practices involves an understanding with plant personnel of the current status of the boiler system, from make-up through condensate, and where the plant can make improvements. This entails doing plant surveys/audits and looking at Best Practices compliance for the system, through the use of the compliance questionnaire which will be detailed later. Figure 1 shows the general process for implementing Best Practices for Boilers.

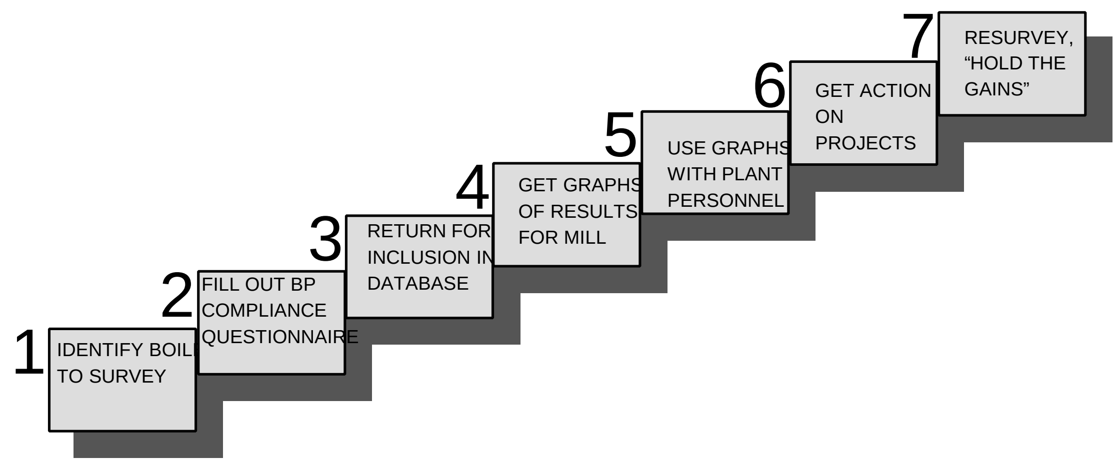

Figure 1. Seven Steps to Implementation of Best Practices for Boilers

The first step in the implementation of Boiler Best Practices is to determine which boilers (and plants) to survey. The larger the results database is, the more useful it is, so the goal would be to survey as many boilers as possible. A survey will consist of physically inspecting the system, from feedwater through condensate, and filling out the Best Practices Compliance Questionnaire. Each feedwater system in a plant must have its own questionnaire but several boilers on one feedwater system may use a single questionnaire, provided sufficient information/detail is included regarding each boiler.

Filling out the Compliance Questionnaire (step 2) involves obtaining basic boiler information such as manufacturer, drum operating pressure, steam flow, percent condensate return, attemperation source, if any, and so on. It consists of 10 sections of objective yes or no questions. This prevents the respondents from having to make judgements on "how good" current practice is. It also makes it easier to assign a value to the projects that are indicated by the questionnaire.

The ten sections examine feedwater system performance and capability, with target limits for mixed-bed, two-bed, and softened water operation, boiler water control capability, regardless of internal treatment program (congruent/coordinated phosphate, residual phosphate, polymer, or chelant treatment). Key control parameters are identified as well as monitoring requirements for grab and continuous sampling, etc.

Questions are also asked about critical analyzers, and whether they are in-place and alarmed. For example, is there an analyzer for sodium in the steam, or for condensate purity? In addition, all surveys must look at whether a preventative maintenance program is in place to make sure the analyzers are working properly! Excursion contingencies should be present, and operator training done regularly for occurrences such as a pH or silica excursion in the boiler water.

Recommended (Best Practices) chemical injection locations are identified along with appropriate injection quills. All possible treatment chemistries are investigated. The way chemicals are fed is also examined--for example, is neat feed used? Is there front end control for the treatment, and how is it controlled, i.e., by mass balance, or inert tracer? And so on.

Due to the severe consequences of contamination reaching the boilers, automated contaminant control systems are part of the recommended Best Practices for Boilers. As with the critical analyzers, there must be preventive maintenance programs in place In addition, Best Practices examines whether the contamination dumps are in the correct place (i.e., with the correct lag time), to actually do their job.

Without proper sampling, you cannot know what is going on in the system, and whether changes need to be made to operations, chemistry, etc. The compliance questionnaire examines whether proper sampling systems are in place for various samples. The last two sections involve questions about resin integrity such as sampling and analysis history, and safety related issues such as Flow Assisted Corrosion.

Once the questionnaire has been filled out, it is entered into the Best Practices Database (step 3). Graphs can then be generated that show the compliance with Best Practices for Boilers of the particular plant surveyed (step 4), as well as how the plant compares to the rest of its corporation, the industry as a whole, or by segment, or by geography. Figures 2 and 3 show some examples of the comparisons that can be made from the results of the survey for a corporation and several plants, or between corporations. Geographic and industry segment comparisons can also be made.

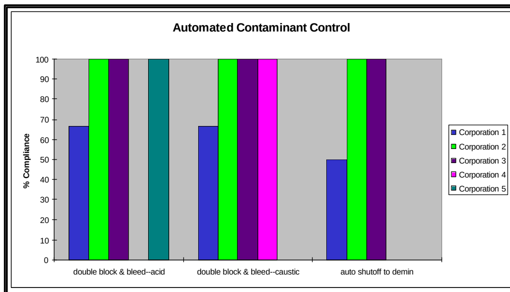

Figure 2. Best Practices Compliance Questionnaire Results for Automated Contaminant Control

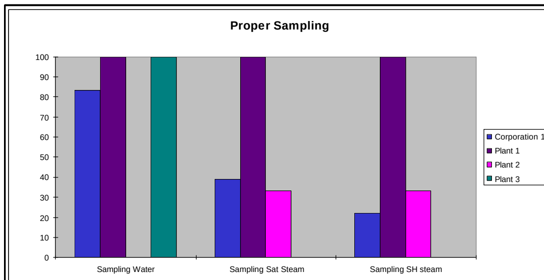

Figure 3. Best Practices Compliance Questionnaire Results for Proper Sampling

Steps 5 and 6 are often done in conjunction, with, or right after, one another presenting information to plant personnel. We then work together with the plant to determine projects to work on, set priorities, and determine costs and savings for each project. To ensure continued improvement toward Best Practices compliance, a survey/audit should be done at least yearly (step 7), including the completion of the Boiler Best Practices Compliance Questionnaire. Yearly updates are often used in annual business reviews, project reviews, etc. to quantify improvements in performance, safety, profitability, and/or reductions in total cost of operations.

INDUSTRIAL EXAMPLES OF BOILER BEST PRACTICES IMPLEMENTATION

Midwestern Greenfield Plant

A Midwestern plant was being built as a Greenfield Project. The plant has a single boiler, making it an even more crucial piece of capital equipment than usual, and the utility operators, although experienced in plant operations, did not have significant boiler operations experience. The plant asked their Nalco representative to help design the proper systems to make sure the boiler was reliable and consistent in operation. The representative trained the plant on Boiler Best Practices and used the cycle diagrams for the appropriate feedwater make-up to select all lab and on-line instrumentation, and to locate all chemical injection points, sample points for grab samples, and the on-line instrumentation. Boiler Best Practices were also used to select the optimal chemical treatment program based on system parameters and feedwater treatment conditions.

By setting up the utility operations "right the first time" and knowing in advance exactly where the optimal (and back-up) locations for all injection, sample points and instrumentation, the plant saved significant installation time. Using the Best Practices as a training tool resulted in minimized training time for the operators and improved training. It was focused not only on the Best Practices, but how those Best Practices were implemented in the plant, as they were being implemented.

The plant estimated that the boiler was available approximately three weeks earlier than it might have been without the guidance of Best Practices. This allowed the plant to make their first product on schedule in late 1999, saved late fees and realized profit on their product. Worker overtime was reduced due to on-schedule production, and the minimized training that was required for operators. A value has not yet been placed on the savings—this will be done in 2000 as metrics are finalized for the plant now that they are in full production.

An intangible benefit was also realized; plant personnel feel more secure in the reliability of the boiler, now and going into the future. Although this feeling is not quantifiable, the lack of unscheduled downtime and maintenance is, and the plant will be keeping track and comparing its operation to the other plants within the corporation which did not start up on Boiler Best Practices. In addition, there are fewer capital improvement projects needed (none identified so far) to get the plant in compliance with Boiler Best Practices. This gives this plant a competitive advantage within the industry.

<u>Boiler Feedwater Automation Project</u>

A southern plant experienced some problems with boiler deposits forming when there were hardness upsets in the feedwater. The internal treatment program was manually controlled, and hardness and internal treatment concentration tests were run on the feedwater twice per 8-hour shift. If an upset was suspected, additional testing was done.

A Best Practice audit was performed on the powerhouse operations in late 1998, and changes were recommended to the boiler internal treatment scheme, but not immediately implemented. After having to unexpectedly clean the boiler and replace several tubes in early 1999, the plant decided to improve their feedwater treatment by changing vendors, chemistry, and the control scheme. An all-polymer chemistry traced with patented TRASAR® technology was implemented on one of the plant's boilers on a trial basis. The boiler feedwater treatment was automated using a TRASAR fluorometer to control feed of the treatment chemistry to a fixed setpoint. A TRASAR fluorometer was also put on the boiler blowdown, in monitoring mode only.

Automatic control kept the treatment in the feedwater at a consistent level, regardless of swings in feedwater flow and steam load, and required minimal opeartor involvement, other than checking the TRASAR® concentration. Polymer concentration was still tested in both the blowdown and the feedwater as a double-check. Feedwater treatment was consistent with TRASAR® levels seen on the automation equipment.

Boiler blowdown was controlled exclusively by conductivity at this plant. When conductivity readings were compared to TRASAR readings, it quickly became apparent that instead of the 50 cycles the plant thought they were running, they were actually closer to 100 cycles (Figure 4). Since the tracer is an inert, non-volatile substance, all of the tracer that is introduced to the boiler remains in the boiler, or is removed *via* blowdown, thus giving a very accurate blowdown calculation by comparing TRASAR concentration in the feedwater with that in the blowdown.

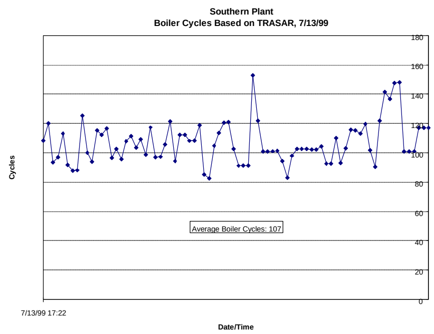

Figure 4. Actual Boiler Cycles based on TRASAR® Readings

The plant was surprised by the information, but took steps to increase blowdown to maintain 50 cycles of concentration, thus optimizing the balance between energy and chemical costs (increased blowdown) and the tendency for increased deposition (decreased blowdown). After six months of automated internal treatment feed during which time cycles of concentration were maintained at ~50 cycles, the boiler was inspected during routine, scheduled maintenance. The boiler had stayed clean ("the cleanest it has ever been"), and no cleaning was needed.

Not having to clean the boiler saved not only the cost of an actual cleaning, but also avoided extending the scheduled maintenance outage, and allowed the boiler to be brought back up quickly, with no reduction in plant productivity. Implementing a recommendation from Boiler Best Practices reduced hassle for the operators, and improved consistent feedwater control and cycle control, while minimizing unscheduled outages and production losses. The plant is in the process of converting the rest of the boilers to automated control, and will repeat the Boiler Best Practices audit. Projects determined from the audit will be prioritized and ROI will be assigned to each.

Boiler Best Practices Implemented across a Corporation

As part of a sole-source bid, Best Practices audits were performed at all the plants of a major corporation during the second half of 1998 to assess current conditions at each plant. Based on the results of these audits, a list of continuous improvement projects was developed for each of the plants in conjunction with plant personnel, and values were assigned to each project. The corporation recognized Best Practices as the method to build value, and monitor the success of project initiation and completion. They decided to implement Best Practices across the corporation. The corporation decided that metrics would be determined by each plant, but discussed between plants, and that corporate metrics would then be developed from plant information.

Projects were identified during the first half of 1999 for all water systems within the plants (not just the boilers), and amounted to a total expected benefit of >$1.3MM for the corporation. This included profitability improvements, as well as total cost of operations reductions. Project update meetings were held periodically at each plant in 1999. By the end of the year, approximately $75K of actual savings had already been realized. Projects were reprioritized, and it was agreed that monthly meetings would be held at each plant to make sure that high priority projects got worked on and additional identified savings could be realized in a timely fashion. Examples of projects involving the boiler systems (and expected savings) at some of the plants included optimizing demineralizer operation ($20K), measuring and optimizing steam usage in the deaerator ($50K), increasing condensate return across the plant by 5% ($400K), improving feedwater and blowdown control through automation (dollar value varies in different plants), extending condensate polisher resin performance ($30K), and improving condensate sampling and monitoring to optimize condensate treatment ($10K).

Based on the experiences of the plants in this corporation, it became apparent that several things are needed for the successful implementation of Best Practices, even when plant personnel have the best of intentions.

Although there are large savings to be realized from implementing Best Practices recommendations, attention must be paid to the projects to ensure that they get completed in the face of sometimes more urgent plant business. When there are many projects that arise from the Best Practices audits, surveys and compliance questionnaires, it is essential to prioritize the projects, assign primary contacts, and determine expected start and completion dates. Priority may be given to the largest return projects, to the easiest projects to complete, or to projects related to safety. These decisions must be made by plant (corporate) management, based on conditions at the plant. The important thing is that priority is assigned, and that a responsible party or parties are identified to champion/monitor the project. Regular update meetings also help to keep projects on track and allow the plant to realize expected savings.

Best Practices audits will be repeated yearly at each plant so that progress can be quantified and improvements benchmarked. This has proven a successful project management tool, allowing each plant and the corporation to identify and prioritize improvement projects that will reduce total cost of operations and/or improve profitability for each plant and the corporation. The total realized benefit is being updated quarterly to ensure progress toward the goals.

SUMMARY

There are many opportunities to improve boiler system performance, efficiency, and safety while reducing the total cost of operations. Boiler Best Practices provides useful tools to achieve these goals. Incorporating all aspects of the system provides a combined approach. Problems can be solved/prevented without creating others in other parts of the system. In fact, more than one problem is often solved with a Best Practices recommendation by understanding how all systems are related.

Implementing regular Best Practices audits helps to ensure that progress is monitored, measured, and tracked so that improvements to the plant provide value to the plant. Boiler Best Practices have successfully been used to set up new boiler systems, to obtain/drive change within individual plants and corporations, as a project management tool, and to drive and demonstrate total cost of operations reductions and profitability improvement. Boiler Best Practices have also helped plants optimize chemical treatment, on-line instrumentation, overall boiler operations, and enhance the safety of the systems, giving plants that implement Boiler Best Practices competitive advantage in their industry.